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Analysis of the Fracture Behavior of Polypropylene - Sawdust Composites

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Abstract: Natural fiber reinforced composite is an emerging area in Polymer science. The use of lignocellulosic materials in thermoplastic composites may contribute to reduce the waste of vegetal biomass. The natural fibers are biodegradable, low cost materials having density and specific properties comparable to those of conventional fiber composites. In this work composites of polypropylene (PP) plus maleated polypropylene (MAPP) filled with sawdust were prepared under fixed processing conditions (mixing temperature, mixing time and rate of rotation). The composites were fractured by tension and the fracture mechanisms were characterized by scanning electron microscopy. The SEM studies of the fractured surfaces of the composites indicate that the failure is due to fiber pull-out accompanied by tearing of the matrix; the pull-out increases with MAPP content.

Keywords: *Composite, polypropylene, sawdust, fracture.*

Introduction

The short-fiber reinforced polymeric composites have gained importance due to considerable processing advantages and improvement in certain mechanical properties. Lignocellulosic-fillers can be obtained either from wood or non-wood vegetable based materials. There is an increasing interest in using non-wood based materials due to the large quantity of biomass generated by Brazilian wood industries as sawdust. Polypropylene-sawdust composites are low cost materials and may contribute to solving environmental problems considering that polypropylene PP is recyclable and have favorable mechanical properties while sawdust is highly available and renewable. It is known that the filler plays an important role in determining the mechanical properties of lignocelluloses filled-thermoplastic composites. One of the main factors that affect the mechanical properties of fiber-reinforced material is the fiber-matrix interfacial adhesion; a weak interfacial region will reduce the efficiency of stress transfer from the matrix to the reinforcement component and low properties can be anticipated. However, the fiber-matrix incompatibility and the poor resistance to moisture can reduce the potential of the composites. The quality of interfacial bonding is determined by several factors, such as the nature of fiber and polymer components, the fiber aspect ratio, the processing procedure and the treatment of the polymer or fiber. The use of a compatibilizer can improve adhesion, and thus, improve the mechanical properties of the composites[1-9]. In the present study the fracture mechanisms of composites consisting of polypropylene (PP) and maleated polypropylene (MAPP) and coated sawdust has been investigated by scanning electron microscopy. The failure mechanisms have been explained on the basis of interfacial fiber-matrix adhesion.

Experimental

Materials

Mixtures of PP, Espheripdol H206 (106,000,$\overline{M}_w$, and 3.8, M_w / M_n), and MAPP, Polybond 3001 (68,000, M_w, and 3.1, M_w / M_n), both supplied by OPP Petroquímica (Brazil), were used as the matrix of the composites; three ratios of PP to MAPP, 98/02, 95/05 and 90/10, were used. The sawdust was obtained from the sawing of cinnamon, cherry, walnut and mahogany tree species; the sawdust fraction was kept at 20% and MAPP was used as a compatibilizer to improve the composite interfacial adhesion. The contents of β cellulose, total cellulose and lignin, in the sawdust blend, were, respectively, 69.7, 81.7

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Table 1. Composition of polypropylene - sawdust composites

Composite	Matrix (80%)		MAPP coated sawdust (%)
	PP (%)	MAPP (%)	
98/02	98	2	
95/05	95	5	20
90/10	90	10	

and 32%. The sawdust was ground three times, screened to 50-mesh size and coated with 22.4 wt% of MAPP through a master batch for 10 min. The composites were prepared in a model 600 Haake Rheomix equipped with a roller mixer-measured head (Table 1). The polymer mixture and the coated sawdust were directly added into the mixing chamber and the composite samples were prepared at 170 °C for 10 minutes in a roller speed of 60 rpm.

Composite molded sheets with, approximately, 1.0 mm thickness were produced at 190 °C and 4 MPa pressure during 5 min in a Carver C press followed by cooling in another press equipped with refrigerator facilities.

Fracture analysis

The fracture in tension was performed at room temperature in a model 4204 Instron Universal Testing Machine with a load cell of 1 kN, at a crosshead speed of 5 mm/min using rectangular specimen of 100 mm x 8 mm, punched out from the molded plates. After the fracture, both fragments of the specimens were collected for analysis. The study of the composite fracture mechanisms was carried out by direct observation of the topography of fracture surfaces of the specimens using a model JSM 5800LV JEOL scanning electron microscope.

Results and Discussion

Figures 1 to 3 present SEM photomicrographs of the tensile fracture surfaces of the PP/MAPP/sawdust composites. The MAPP addition to PP-sawdust composite does not modify the basic fracture mechanism of the PP matrix[8]. The composite failed, predominantly, by transversal fracture in the plane of the matrix, showing similar fracture features: surface roughness and the presence of conic marks. However, one can see that the increase in the MAPP content and the addition of sawdust produce modifications in the matrix surface with pull-out and breakage of the fibers. In this manner the fracture morphology of the composites shows some differences according the PP/MAPP ratios. The SEM photomicrographs of the 98/02 composites (Figure 1) show an effective fiber-matrix adhesion. It can be seen, that a layer of the matrix material that have been pulled out together with the fiber. This is an indication that at this MAPP content occurs an effective interaction between the sawdust filler and the PP/MAPP matrix.

In the 95/05 composites it is observed the existence of cracks in the matrix-filler interface and, in consequence, a

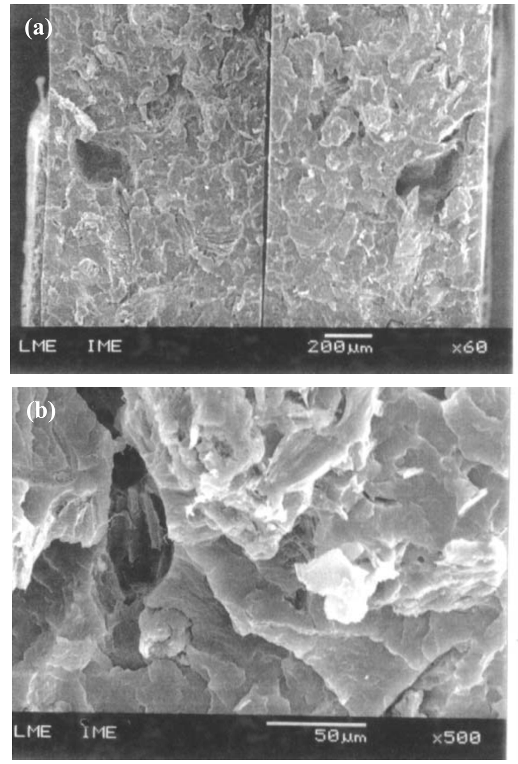

Figure 1. SEM photomicrographs of tensile fracture surfaces of 98/02 PP/MAPP composite: general view; (b) detail of (a)

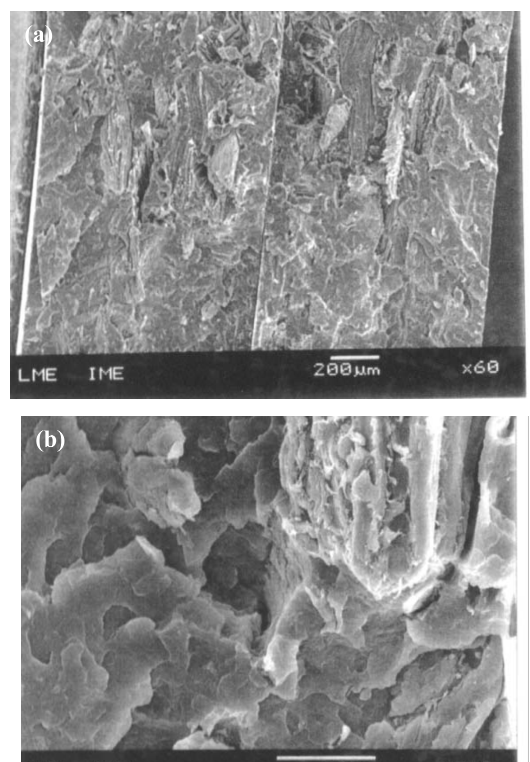

Figure 2. SEM photomicrographs of tensile fracture surfaces of 95/05 PP/MAPP composite: general view; (b) detail of (a)

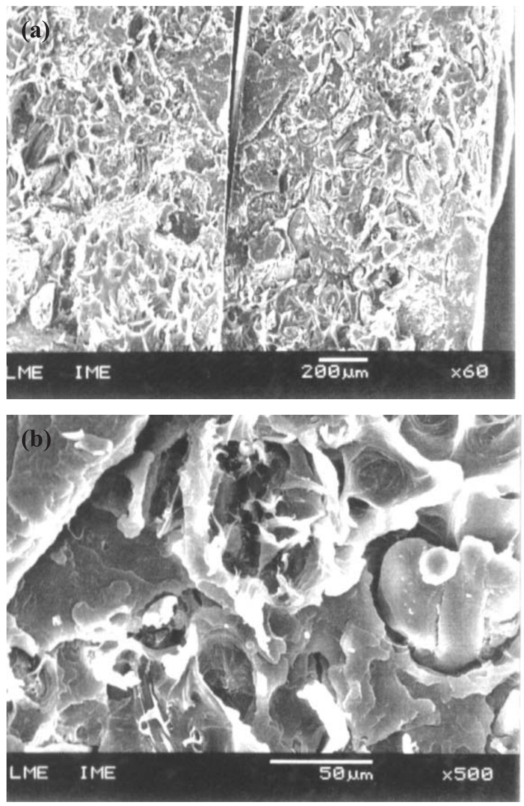

Figure 3. SEM photomicrographs of tensile fracture surfaces of 90/10 PP/MAPP composite: general view; (b) detail of (a)

worse interfacial adhesion between the sawdust and the PP/MAPP matrix (Figure 2). In addition to fiber pull-out, as the mode of fracture, fiber breakage can also be seen in the samples. The photomicrographs of the 90/10 composites (Figure 3) exhibit cracks and a concentration of holes left after the fibers are pulled out from the matrix. The holes proximity indicates that the sawdust exist in the form of fiber bundles that did not provide an efficient stress transfer from the matrix to the fiber.

Conclusions

The experimental results lead, considering the used processing conditions (170 °C, 10 minutes, 60 rpm), to the following conclusions:

1) The addition of 2 % of maleated polypropylene (MAPP) to polypropylene (PP) provides an effective fiber-matrix adhesion and permits to achieve good tensile characteristics in PP/MAPP/sawdust composite.

2) The addition of high percentage of MAPP to PP decreases the interfacial matrix / sawdust adhesion and it is expected to occur a reduction in the tensile strength of PP/MAPP/sawdust composite.

3) The mechanical properties of PP/MAPP/sawdust composites can be predicted in terms of interfacial adhesion fiber-matrix.

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References

1. Takase, S.; Shiraishi, N. - J. Appl. Polym. Sci.,, 37, p.645 (1989).

2. Felix, J.M.; Gatenholm, P. - J. Appl. Polym. Sci., 42, p.609 (1991).

3. Bledzi, A.K.; Reihmane, S.; Gassan, J. - Polym.-Plast. Technol. Eng., 37 (4), p.451 (1998).

4. Nabi Saheb, D.; Jog, J.P. - Adv. Polym. Tech., 18 (4), p.351 (1999).

5. Felix, J.M.; Gatenholm, P. - Polym. Composites, 14 (6), p.449 (1993).

6. Kim, J.-K.; Lu, S.; Mai, Y.-W. - J. Mater. Sci., 29, p.554 (1994).

7. Valadez-Gonzalez, A.; Cervantes, J.M.; Olayo, U.C.R.; Herrera-Franco, P.J. - Composites: Part B, 30, p.309 (1999).

8. Coutinho, F.M.B.; Costa, T.H.S.; Miguez Suarez, J.C.; Melo, D.P. - Polym. Testing, 19, p.625 (2000).

9. Pochiraju, K.V.; Tandon. G.P.; Pagano, N.J. - J. Mech. Phys. Solids, 49 (10), p.2307 (2001).